CRUISING PERFORMANCE OF INDONESIAN RO-RO FERRIES UNDER ACTION OF WIND AND WAVES

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SUMMARY

The ro-ro ferries play an important role in Indonesian sea transportation. Therefore, performance of the Indonesian ro-ro ferries in operation become important in technical and economical point of view. This paper discusses effect of wind and wave to the ship speed, drift and rudder angle in order to maintain the ship direction. The wind velocities of 5 m/s, 10 m/s, 15 m/s, 20 m/s and 25 m/s with variation of direction from 0 degree (head wind) to 180 degrees (following wind) are used to investigated its effect on ship speed, drift angle and rudder angle. The wave is assumed to be fully developed due to wind. Therefore the wave parameters are determined using wind and wave correlation as defined in Beaufort scale. These environment parameters are used to numerically solve the maneuvering equation based on MMG model by using the Newton-Rhapson method.
Results of the numerical simulation show that the wind effect to the drift angle become significant in the wind and wave direction less than 80.0 degrees. In this range of wind and wave direction, effect of wave height is neglected small. The 0 effect of wave on the drift angle tends to be increase in range of wind and direction from 80.0 degrees up to 180.0 degrees. The encessary rudder angle is dominantly affected by the wind in the wind and wave direction of 40.0 degrees or larger. The wave effect becomes significant in the wind and wave direction is smaller that 100.0 degrees. The ship speed is significantly affected by the wind velocity compared with the effect of wave height. The effect of wave height to the ship speed occurs in the range of wind and wave direction from 20.0 degrees up to 100.0 degrees.

NOMENCLATURE

A_E	Propeller blade expanded area (m^2)
A_R	Rudder area (m^2)
A_0	Area of propeller blade (m^2)
a_H	Interaction factor of hull and rudder
$B(x)$	breadth of section (m)
D_P	Propeller diameter (m)
$d(x)$	Draught of section (m)
I_{zz}	Moment of inertia in yaw (kN m rad^{-1})
J	Advance coefficient
K_T	Thrust coefficient of propeller
k	Wave number
m	Ship mass (ton)
N	Moment resultant in yaw (kN m)
N_A	Wind moment in yaw (kN m)
N_H	Hull moment in yaw (kN m)
N_P	Moment of propeller in yaw (kN m)
N_R	Rudder moment in yaw (kN m)
N_W	Wave moment in yaw (kN)
n	Propeller revolution (rps)
P	Propeller pitch
r	Yaw rate (rad s^{-1})
$\dot{r}$	Angle acceleration in yaw (rad s^{-2})
$S(x)$	Sectional area (m^2)
$S_y(x)$	Added mass of section in sway (kN)
u	Surge velocity (m s^{-1})
$\dot{u}$	Surge acceration (m s^{-2})
v	Sway velocity (m s^{-1})
$\dot{v}$	Sway acceleration (m s^{-2})
w_p	Wake friction of propeller
X	Forces resultant in surge (kN)
X_A	Wind force in surge (kN)
X_H	Hull force in surge (kN)
X_P	Propeller thrust (kN)
X_R	Rudder force in surge (kN)
X_W	Wave force in surge (kN)
x_G	Longitudinal center of gravity (m)
x_H	Position of Hull-rudder interaction (m)
x_R	Longitudinal position of rudder (m)
Y	Forces resultant in sway (kN)
Y_A	Wind force in sway (kN)
Y_H	Hull force in sway (kN)
Y_P	Propeller thrust in sway (kN)
Y_R	Rudder force in sway (kN)
Y_W	Wave force in sway (kN)
Z	Number of propeller blade
z_R	Vertical center of gravity of rudder (m)
ε_R	Wake ratio of propeller and hull
κ_P	Interaction of propeller and rudder
ρ	Density of water (kg m^{-3})
ω	Wave frequency (rad s^{-1})
ω_e	Wave encounter frequency (rad s^{-1})
ζ_W	Wave amplitude (m)
ξ_G	Ship trajectory (m)
χ	Wind and wave direction (rad)
λ	Wave length (m)

1. INTRODUCTION

As an archipelago country with distance between the islands quite short, interisland transportation becomes the most important transportation system in Indonesia. Recently, there are more than 100 routes of interisland transportation have be operated with more than 150 ro-ro ferries. Therefore, safety and economic aspects in operation of the Indonesian ro-ro ferries become important in order to ensure effectively of the interisland transportation. With the last two decades, more 600 accidents of ships occurred in Indonesian seaways and 15